MARTIAN SURFACE WATER RESERVOIR. J. Audouard[1], F. Poulet[1], M. Vincendon[1], R. E. Milliken[2], D. Jouglet[3], J.-P. Bibring[1], B. Gondet[1] and Y. Langevin[1], [1]Institut d'Astrophysique Spatiale (UPSUS/CNRS) Orsay, France; [2]Dept. Geological Sciences, Bown University, Providence, RI, USA; [3]CNES, Toulouse, France. Contact: joachim.audouard@u-psud.fr

Introduction: Several resevoirs of water have been identified on Mars. We investigate one of them, the hydration of the Martian regolith and rocks, identified by a broad absorption near ~3 µm. Such a band was early remarked in spectroscopic infrared (IR) remote-sensing observations of the Martian surface [1, 2, 3]. This absorption is seen in every ice-free spectra of modern IR orbital datasets such as OMEGA/MEx and CRISM/MRO and has been interpreted as being caused by H2O and OH molecules [4, 5].

Depending on the mineral host, but also on temperature and relative humidity, H_2O and OH molecules can be "structural" (e.g. solvation water in smectites clays), "bound" or "chemisorbed" (i.e. covalently bound to the mineral metals and defects), or "adsorbed" or "physisorbed". Some of these water phases are expected to be exchangeable with regards to today's Martian conditions and in relation to the observed seasonal and diurnal variations of water vapour in the Martian atmosphere [6, 7, 8].

MSL recent in situ results at Gale Crater revealed an ubiquitous and diurnaly constant Hydrogen signal in LIBS spectra of the top µm of the surface [9]. The SAM experiment measured a release of water vapour mostly at high temperatures, indicating a bulk water content of Rocknest's soil top cm of 1.5-3 wt. % consistent with tightly bound water molecules [10]. X-ray diffraction spectra reveal that this water is mostly present in the amorphous phase of Rocknest's soil [11]. [9] thus proposed that the global distribution of the water content seen in Near-InfraRed (NIR) orbital datasets may indicate varying abundance of the amorphous component at the surface.

This work aims at readdressing the 3 µm absorption distribution and variations with the entire NIR spectrometer OMEGA dataset (i.e. more than four full Martian years of observations), using recent laboratory experiments [12, 13] and data processing updates [14].

Data processing and method: We use data from OMEGA instrument onboard Mars Express, which is an imaging spectrometer covering the wavelength range 0.36-5.1 µm and orbiting Mars since 2004 [15]. Recent developments by [16] and validation by [14] allow the use of the long wavelength (covering the 3 µm absorption) non-nominal orbits for scientific studies. ~6200 OMEGA datacubes were processed for this study, representing more than four full Martian years of orbital data and achieving a global coverage. Specific OMEGA long wavelength channel filtering described in [14] have been applied. Water icy frost at the surface have been excluded from this analysis using the 1.5 µm band depth described in [17] as well as water ice clouds by the mean of the 3.5 µm slope index [17]. Observations with high atmospheric dust load were also removed. Atmospheric attenuation and Mars thermal contribution are accounted for using the method described in [14] and converted to reflectance factor. OMEGA reflectance spectra are then linearized to effective single-particle abrosption thickness (ESPAT). Laboratory experiments [12, 13] have revealed that the ESPAT parameter at 2.9 µm is linearly correlated to the water content of a set of minerals (montmorillonite, palagonite) with various admixtures of neutral darkening agents. For these samples, the ESPAT parameter at 2.9 µm is relatively independent on composition and albedo but still remains strongly dependent on particle size. We use the relationship provided for <45 µm sieved samples because this size fraction is expected to dominate the spectral response of the Martian surface [5].

Results: The global map of water wt. % is presented in Figure 1 and apparent variations with latitude and season are presented in Figure 2. Previously reported seasonal variations [4, 5] are not observed in the present work. After careful analysis of the data, we estimate that this discrepancy is due to the water ice clouds filtering used in our work. Our water wt. % values are observed to vary with the mineralogical composition: in particular, hydrous minerals appear more hydrated than surrounding terrains and chloride-bearing deposits appear dessicated relatively to surrounding terrains. The value over Gale crater northern plains (4.6 ± 0.5 wt. %) is consistent with recent MSL results, given the uncertainties.

The water wt. % distribution of Figure 1 is not correlated to surface particle size proxy such as thermal inertia [14]. Low latitudes (< 45°) water wt. % values are not correlated to albedo but high latitudes water wt. % values increase with incresing dust abundance.

Apparent seasonal variations of Figure 2 are not attributable to actual changes in surface hydration but rather to seasonally varying atmospheric dust load. The water wt. % values do not show any correlation for any type of terrain at any latitude with relative humidity values predicted as a function of time and location by 3D GCM simulations [18].

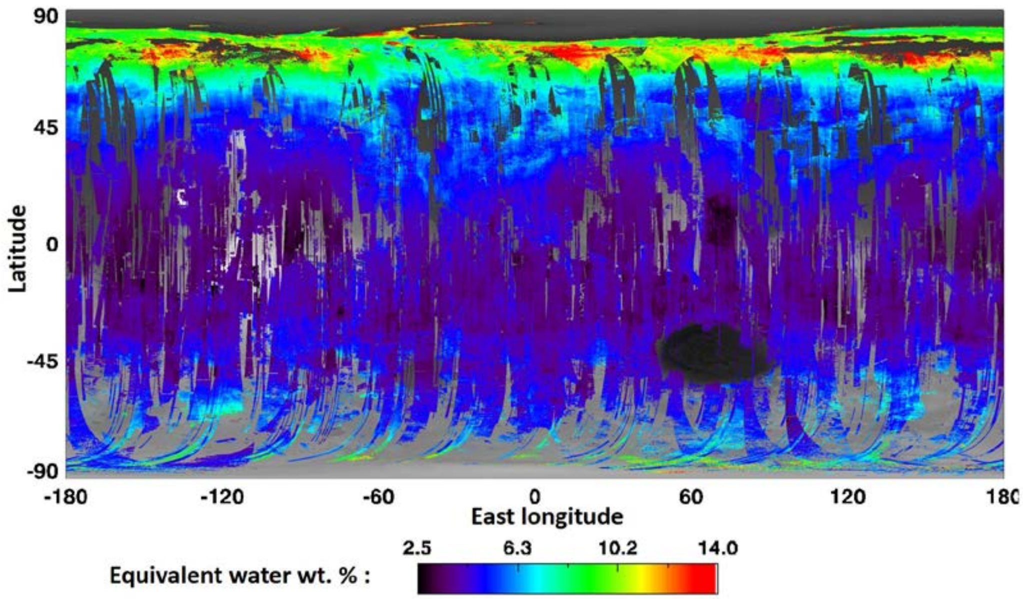

Figure 1. *Global map of the optical surface water wt. % at a resolution of 32 ppd. ~40 million OMEGA spectra have been filtered and processed to build this map. A background (model-dependent) level of 4±1 wt. % is observed.*

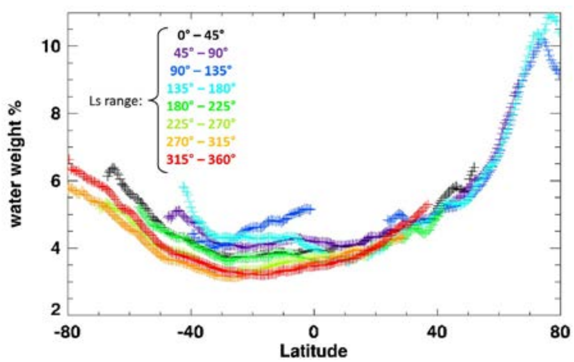

Figure 2. *Apparent variations of water wt. % with latitude and season (indicated in different colors). Some residuals of water ice clouds are visible in this plot, for instance at latitude = 10°S for Ls=90-135°.*

On the other hand, we infer that the increase of surface hydration latitude and the North/South dichotomy could be explained by water frost and ice deposition at the surface. Water frost is deposited at the surface when the relative humidity is equal to 1, but only when the partial pressure of water vapour is sufficient. Since the partial pressure of water vapour is much lower in the southern high latitudes, lower values of surface hydration are indeed expected. Another hint for such a frost-related hydration implementation is the correlation of surface hydration with dust abundance in the high latitudes, as dust provides higher surface of contact of the regolith with the water frost. Our view of the top surface hydration therefore potentially reveal the process of water implementation into the Martian regolith.

In summary, the apparent hydration of the Martian optical surface:

- Presents a background (model-dependent) level of 4±1 wt. %.
- Is apparently not exchangeable with the atmosphere on diurnal or seasonal timescales.
- Is stable with regards to the present-day water cycle of Mars, contrarywise to buried hydrogen sources detected by GRS.
- Varies with latitude, with a non-ambiguous North/South dichotomy.
- Varies with the mineralogical composition, revealing the importance of structural water.
- Is best explained by frost deposition as occurring today at the high latitudes of Mars.

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